Forward Looking Statements

ASML

Public

This document contains statements relating to certain projections and business trends that are forward-looking, including statements with respect to productivity of our tools and systems performance, EUV system performance, expected industry trends, and EUV targets (including availability, productivity and shipments) and roadmaps. You can generally identify these statements by the use of words like "may", "will", "could", "should", "project", "believe", "anticipate", "expect", "plan", "estimate", "forecast", "potential", "intend", "continue" and variations of these words or comparable words. These statements are not historical facts, but rather are based on current expectations, estimates, assumptions and projections about the business and our future financial results and readers should not place undue reliance on them. Forward-looking statements do not guarantee future performance and involve risks and uncertainties. These risks and uncertainties include, without limitation, the impact of manufacturing efficiencies and capacity constraints, performance of our systems, the continuing success of technology advances and the related pace of new product development and customer acceptance of new products, the number and timing of EUV systems expected to be shipped and recognized in revenue, delays in EUV systems production and development, our ability to enforce patents and protect intellectual property rights, the risk of intellectual property litigation, availability of raw materials and critical manufacturing equipment and other risks indicated in the risk factors included in ASML's Annual Report on Form 20-F and other filings with the US Securities and Exchange Commission. These forward-looking statements are made only as of the date of this document. We do not undertake to update or revise the forward-looking statements, whether as a result of new information, future events or otherwise.

EUV lithography performance for manufacturing: status and outlook

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SPIE 2016

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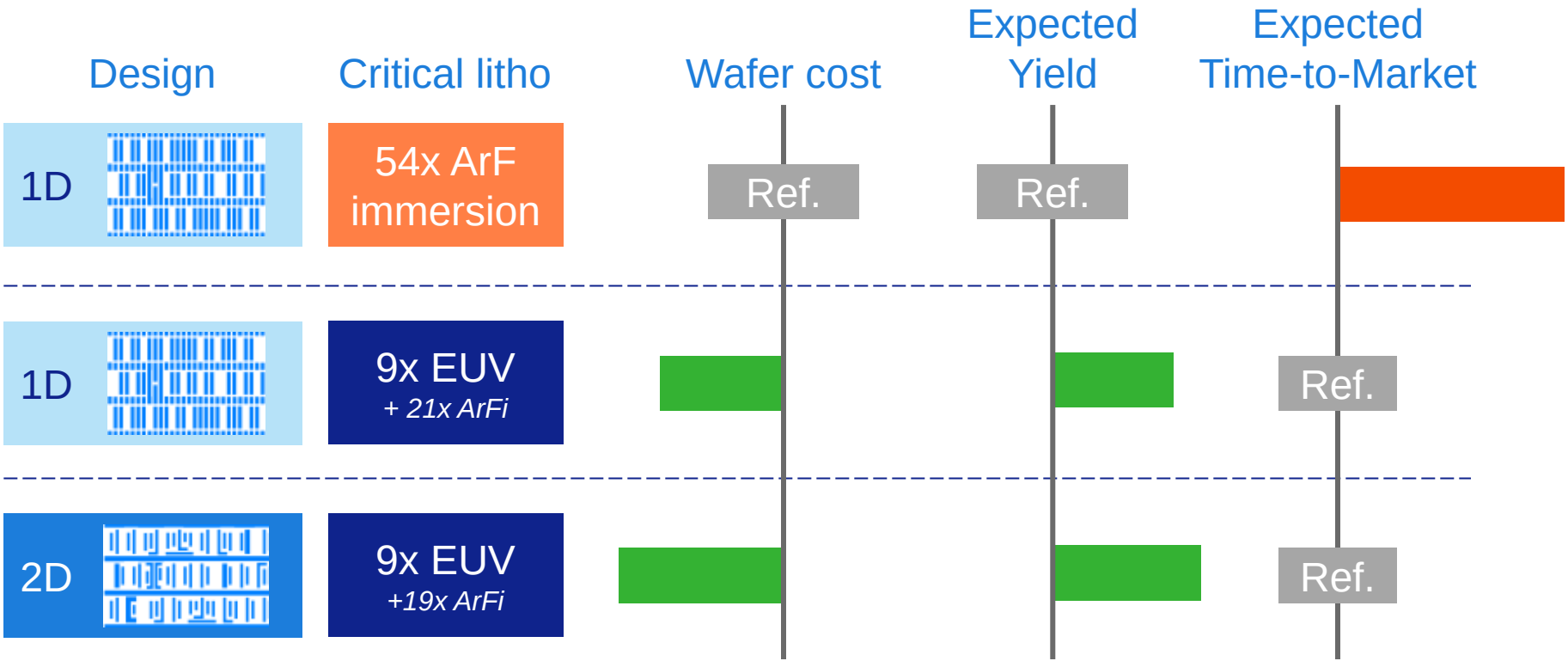
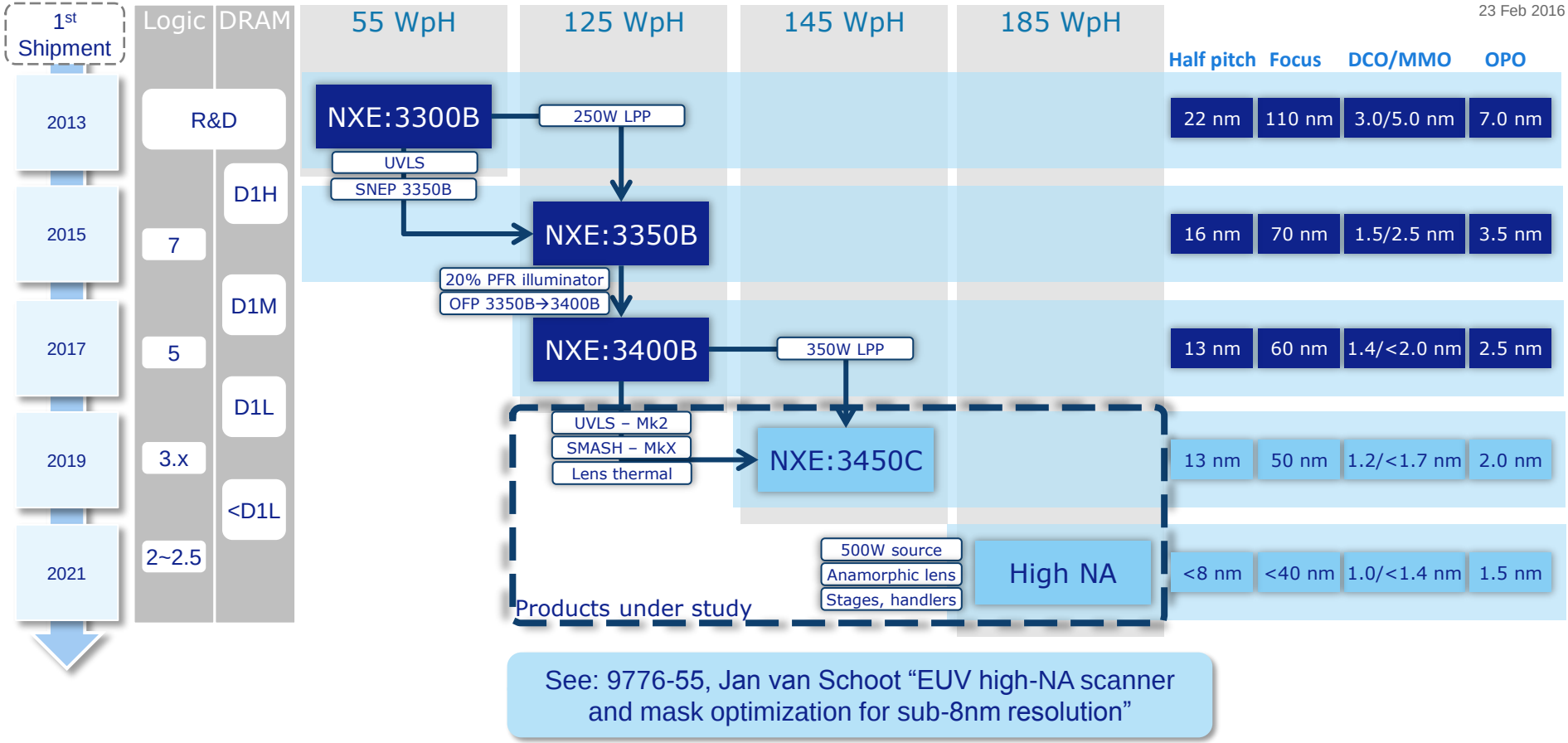
- Alex Schafgans
- Igor Fomenkov
- Michael Lercel
- David Brandt
- Geert Fisser

EUV provides lower cost, higher yield, faster time to market



NXE extension roadmap to optimize capital efficiency



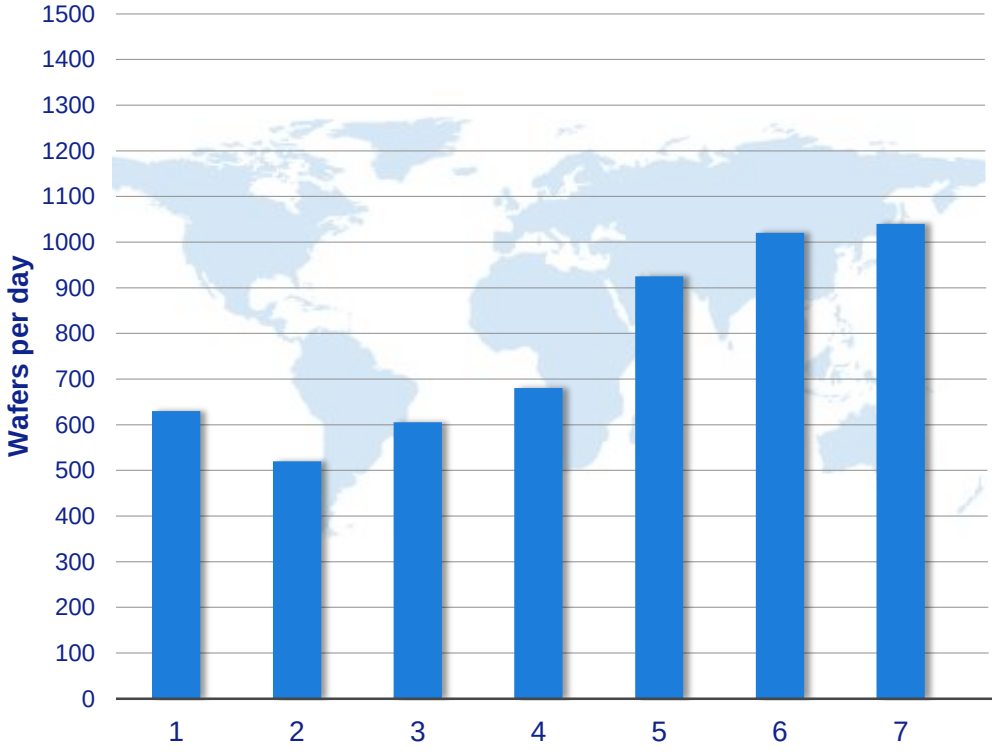
See: 9776-55, Jan van Schoot “EUV high-NA scanner and mask optimization for sub-8nm resolution”

Outline

- Throughput & Wafers per Day (WpD)
- Availability
- Defectivity, imaging and overlay

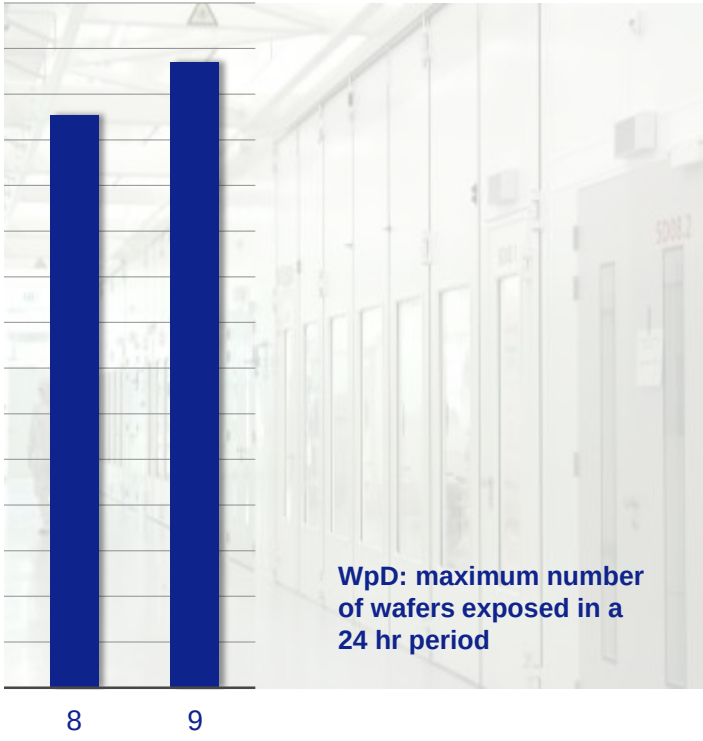
Wafers per day capability: multiple NXE:3300B above 1,000 NXE:3350B demonstrated 1,368

NXE:3300B at customers



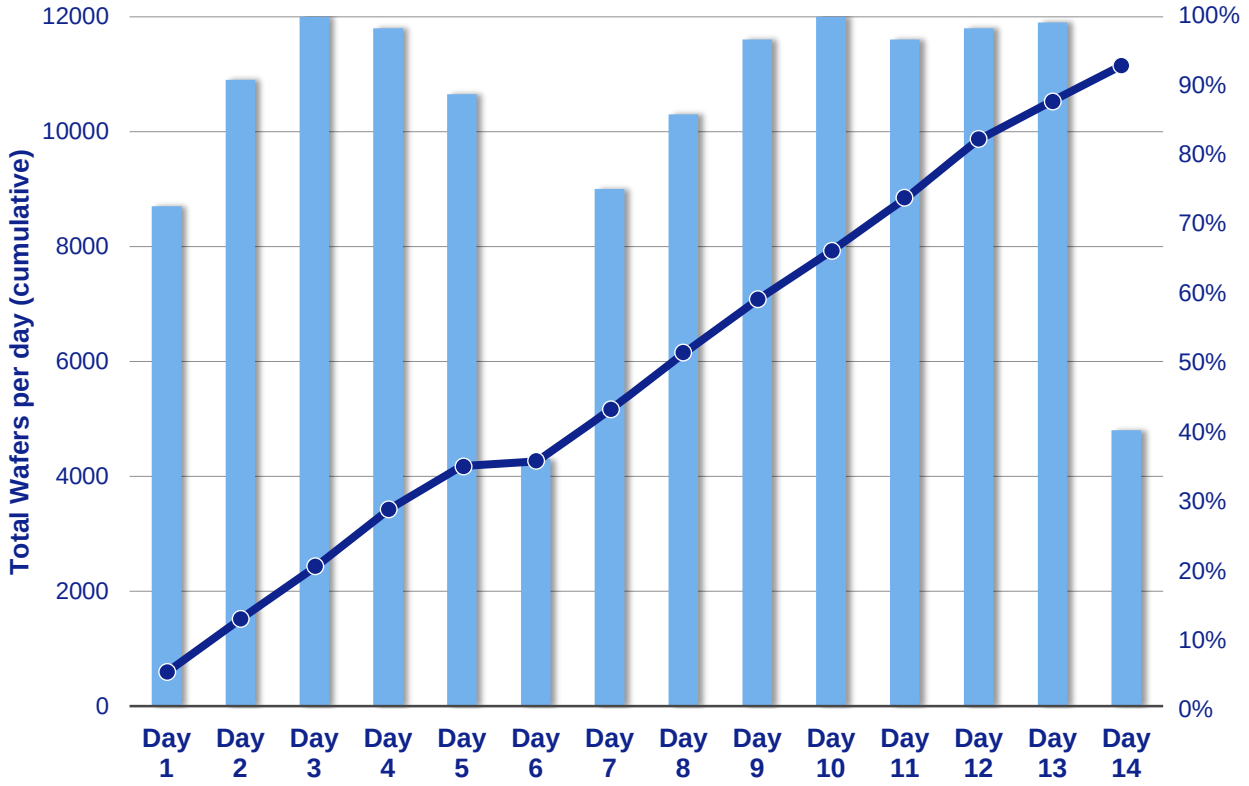
NXE:3300B today: 6 systems in 80W configuration, 2 in 40.W
One year ago: 1x80W, 5x40W

NXE:3350B at ASML factory



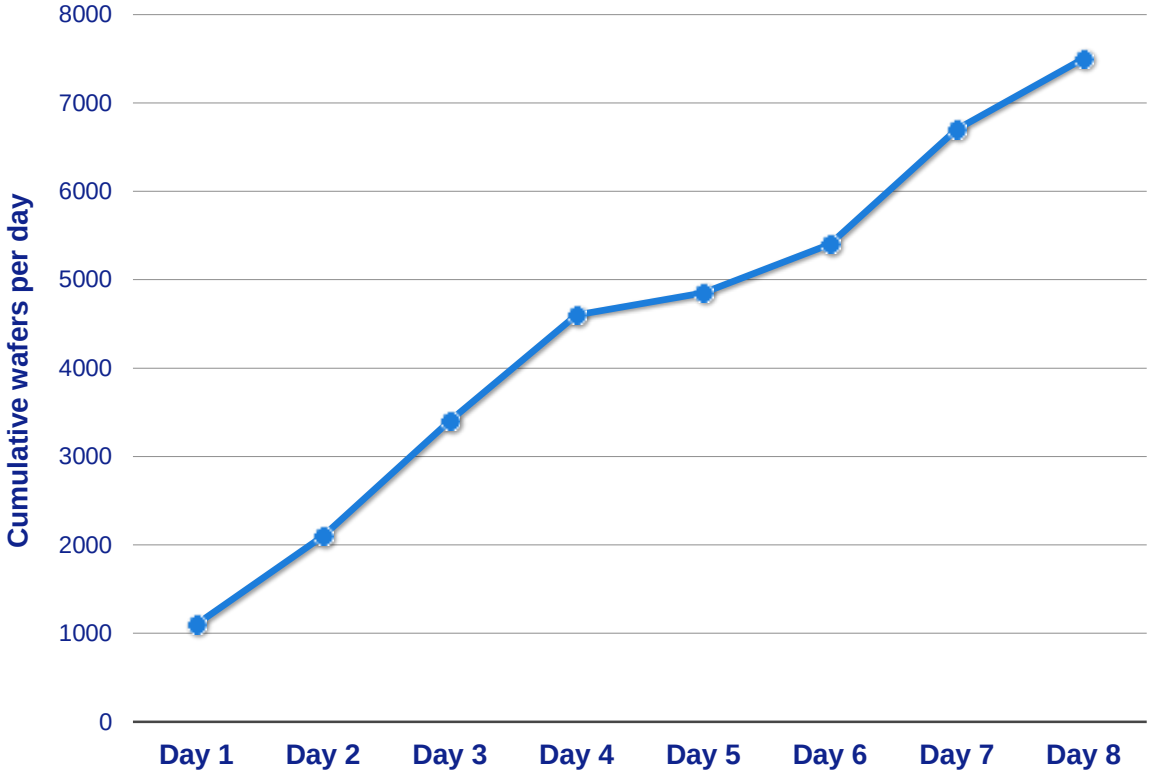
NXE:3350B ATP test: 96 fields, 20mJ/cm2

NXE:3300B productivity at customer: average ~800 wafers per day over multiple weeks



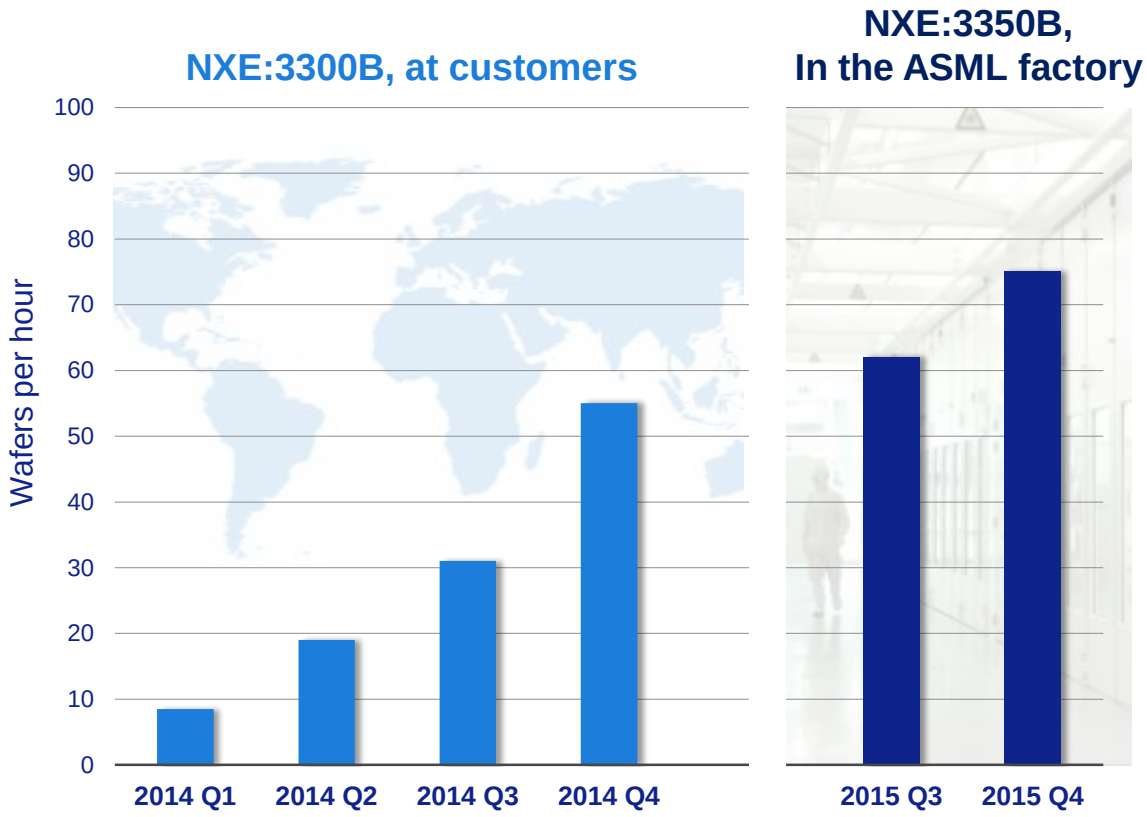
Total Exposed wafers	11174
AVG WPD	798
AVG availability	85.7%

NXE:3350B productivity in ASML factory: ~950 wpd average over 8 days



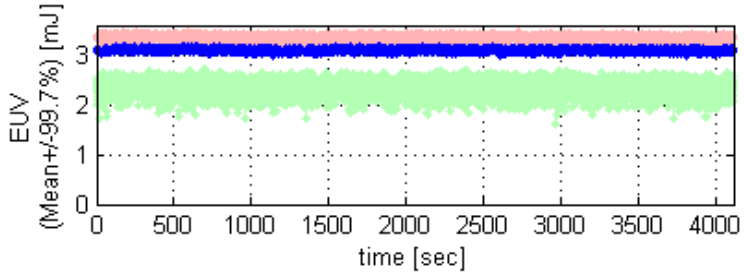
Demonstrated 75 WpH on NXE:3350B

Further improvements with 125W settings

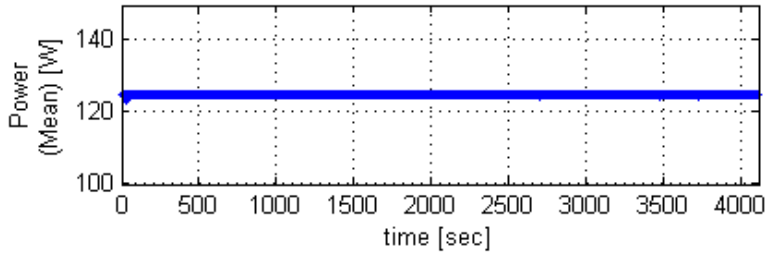


NXE:3500B ATP test: 26x33mm2, 96 fields, 20mJ/cm2

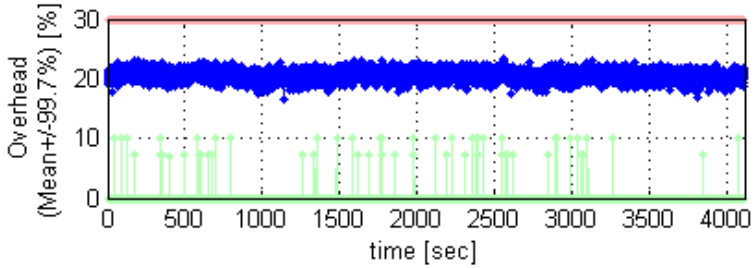
NXE:3350B: 125W settings qualified and ready for field roll out



Mean pulse energy at Intermediate Focus ~3mJ



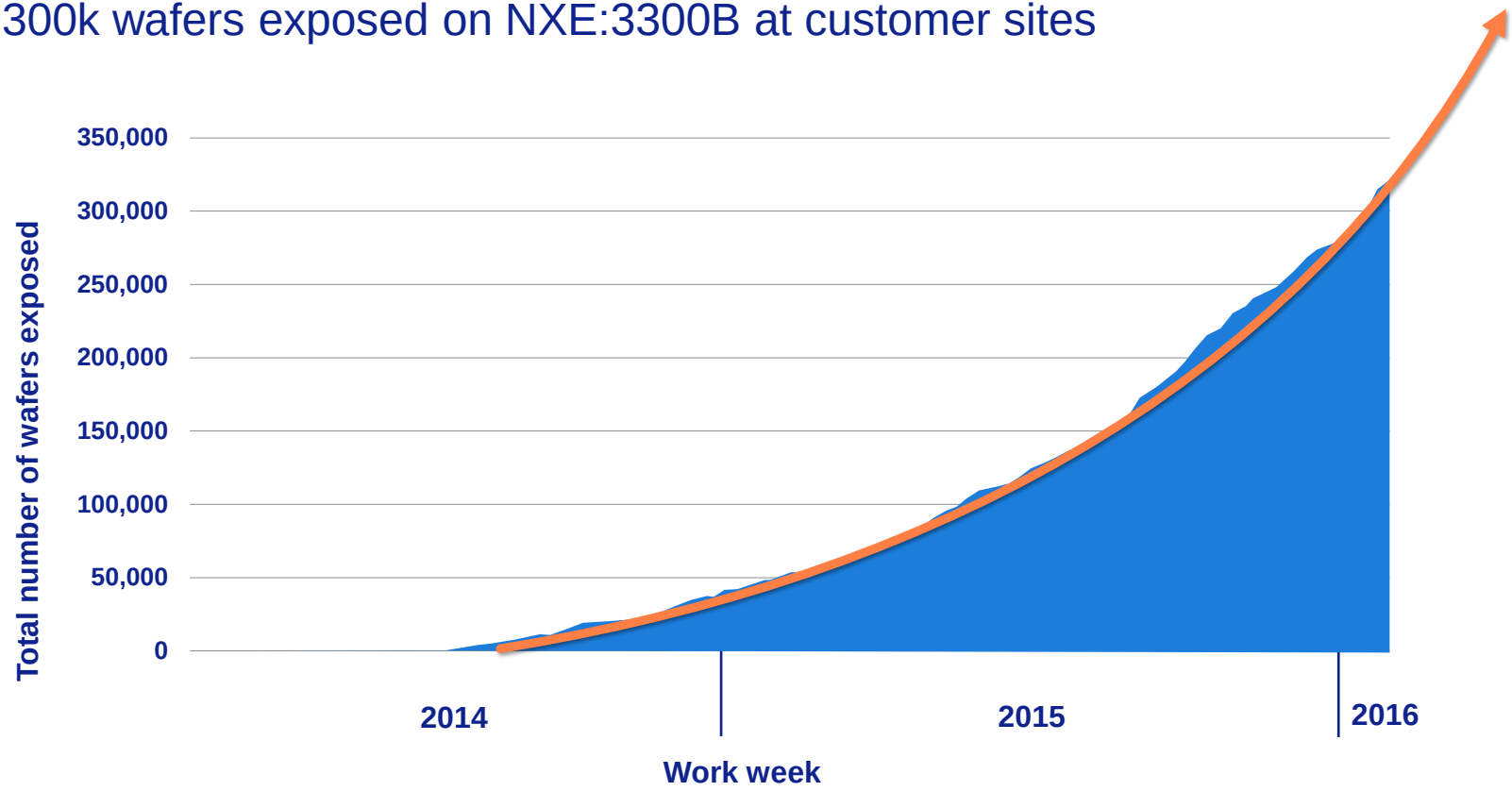
EUV power at Intermediate Focus 125W



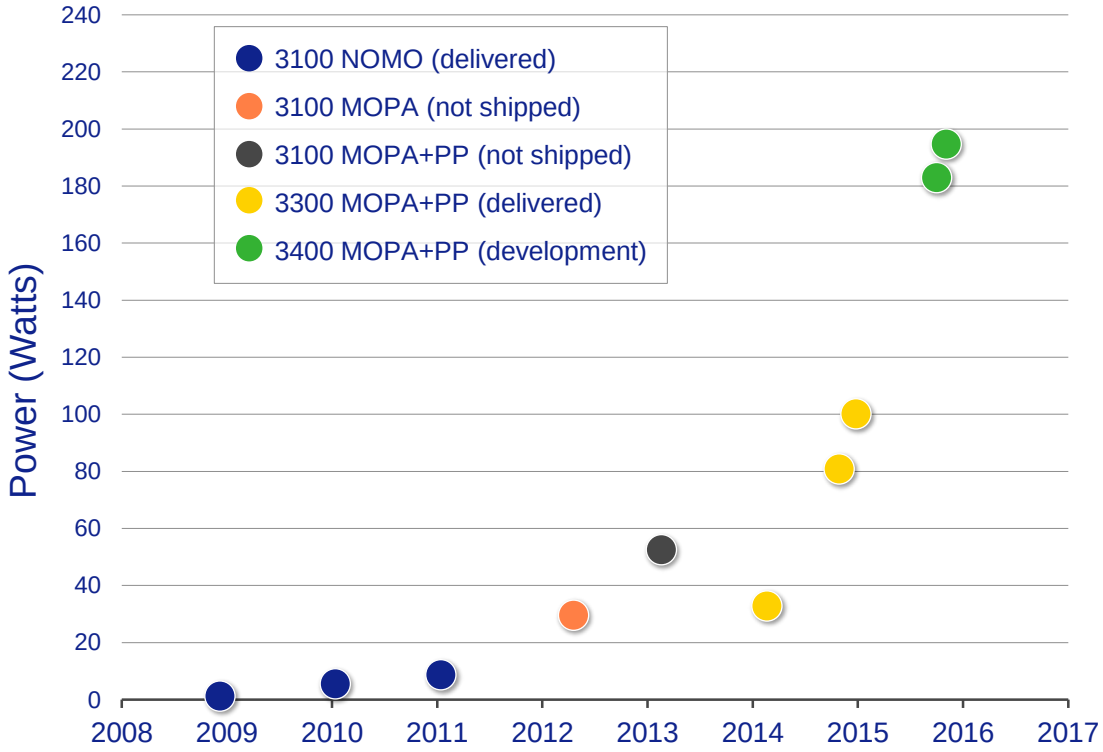
Energy control Overhead ~20%

NXE:3300B productivity supports customer process development

>300k wafers exposed on NXE:3300B at customer sites



Acceleration in power scaling towards >200W builds further confidence in EUV productivity



See: 9776-21, Michael Purvis "Advances in predictive plasma formation modelling"

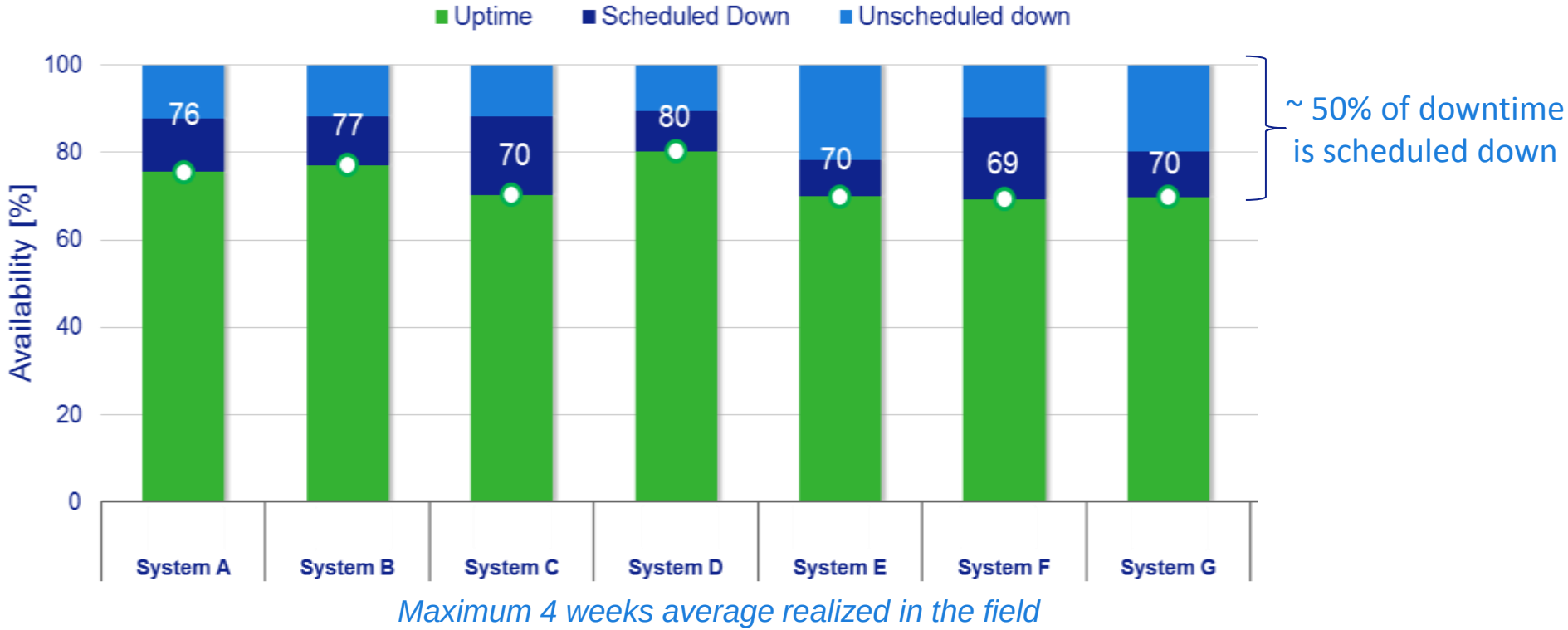
See SPIE 2015, 9422-10, Alex Schafgans, "Performance optimization of MOPA pre-pulse LPP light source"

Outline

- Throughput & Wafers per Day (WpD)
- Availability
- Defectivity, imaging and overlay

Availability: capability beyond 75% proven on multiple field systems

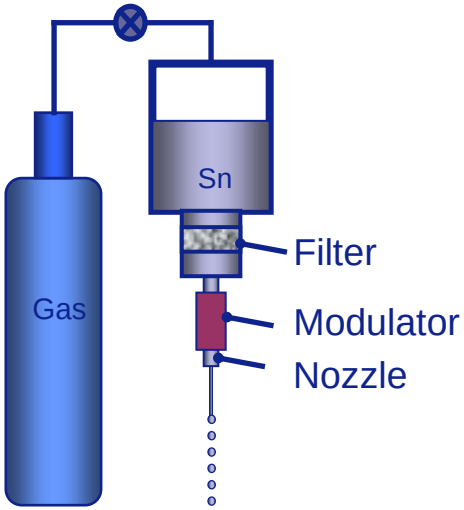
2016 focus: reduce scheduled maintenance, reduce variability



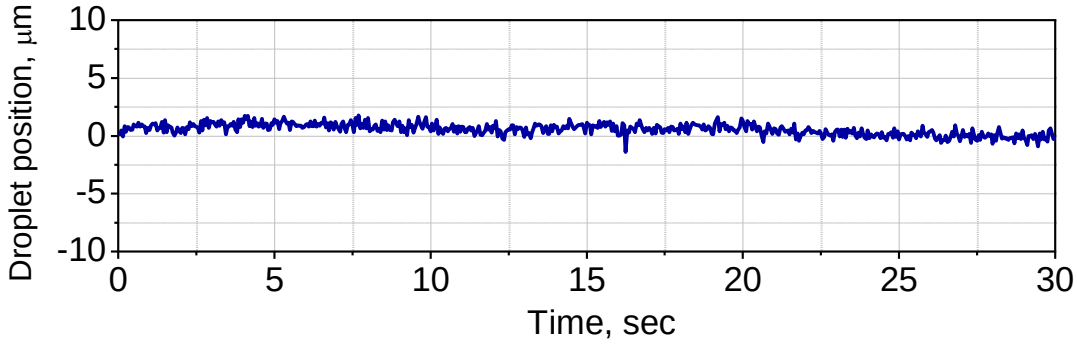
Maximum 4 weeks average realized in the field

Uptime = productive time + standby time + engineering time

Droplet Generator: Principle of Operation

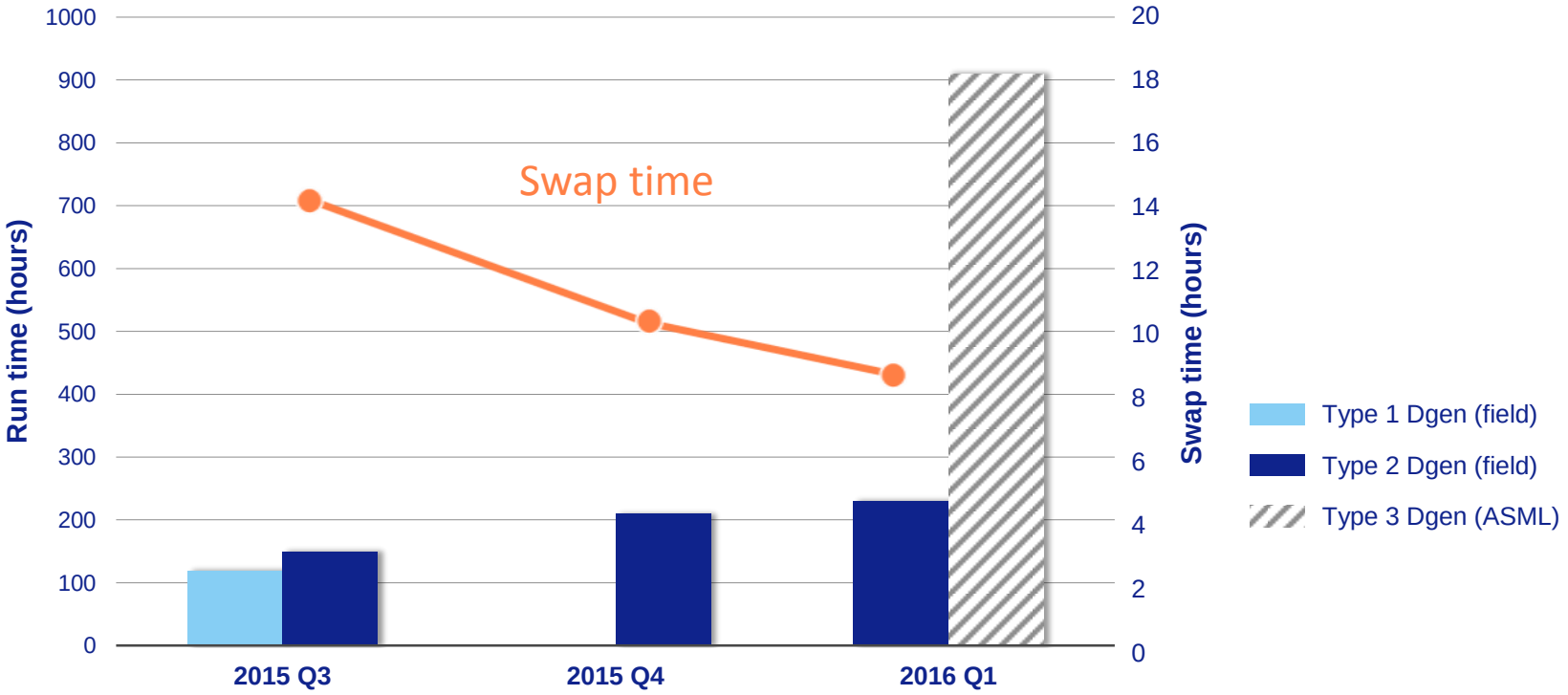


- **Tin is loaded in a vessel & heated above melting point**
- **Pressure applied by an inert gas**
- **Tin flows through a filter prior to the nozzle**



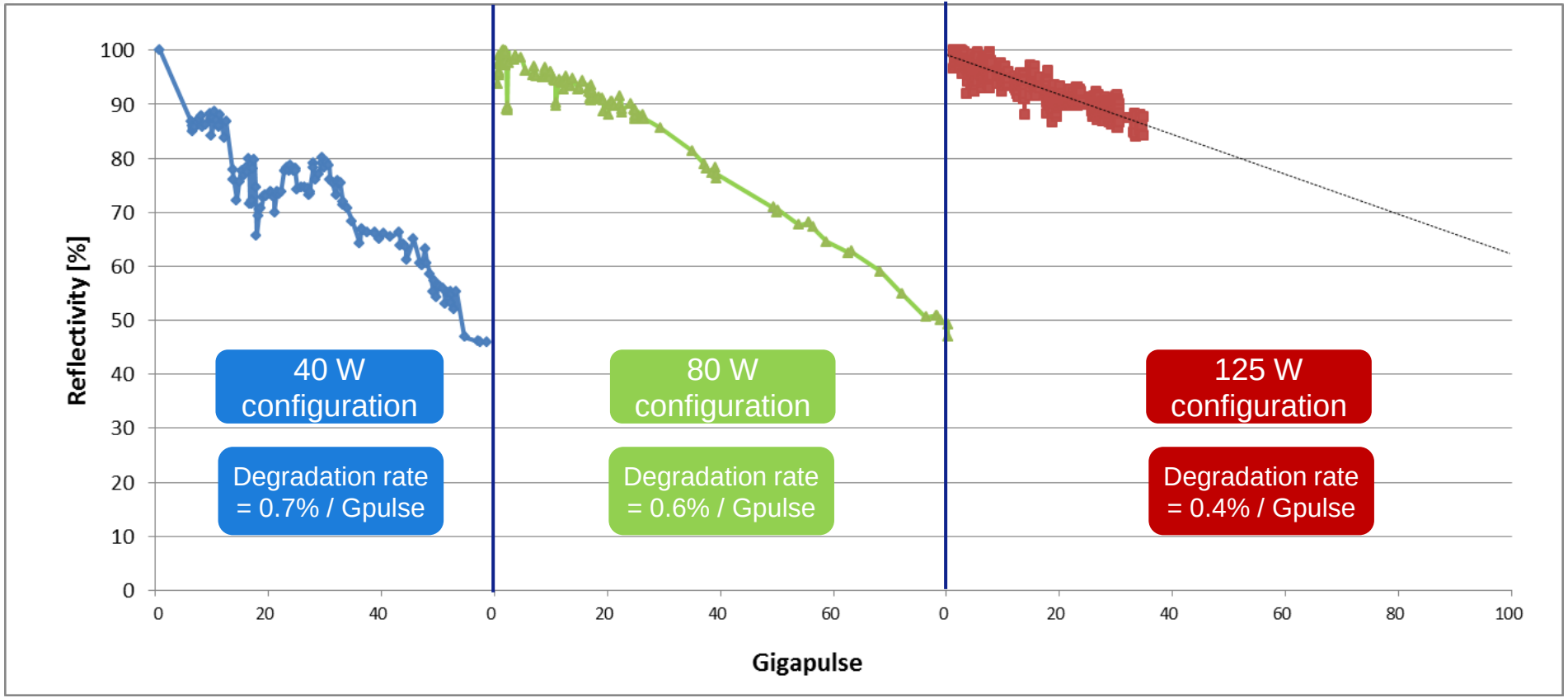
Droplet Generator: ~2x improvements in run time, swap time

Next generation DGen: demonstrated > 1 month lifetime capability



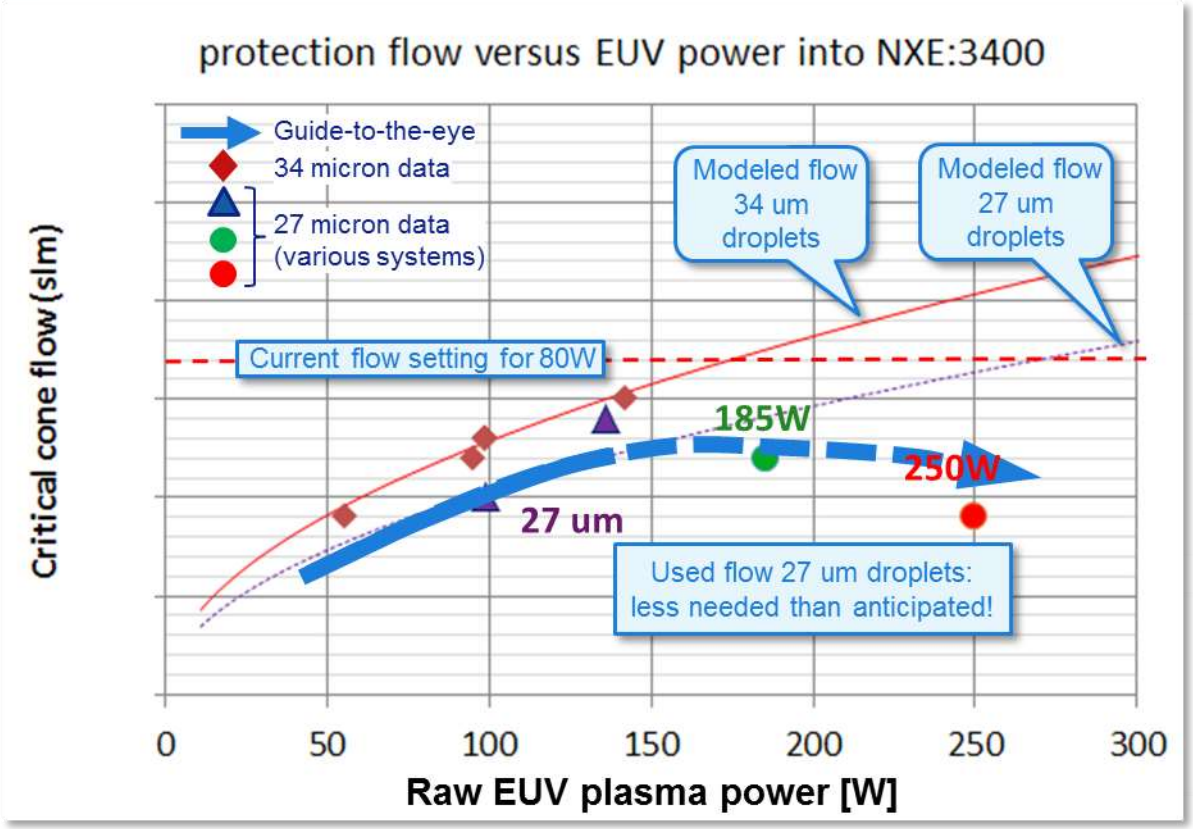
Continuous improvements in collector protection at increasing power

100 Gpulses capability demonstrated at 125W

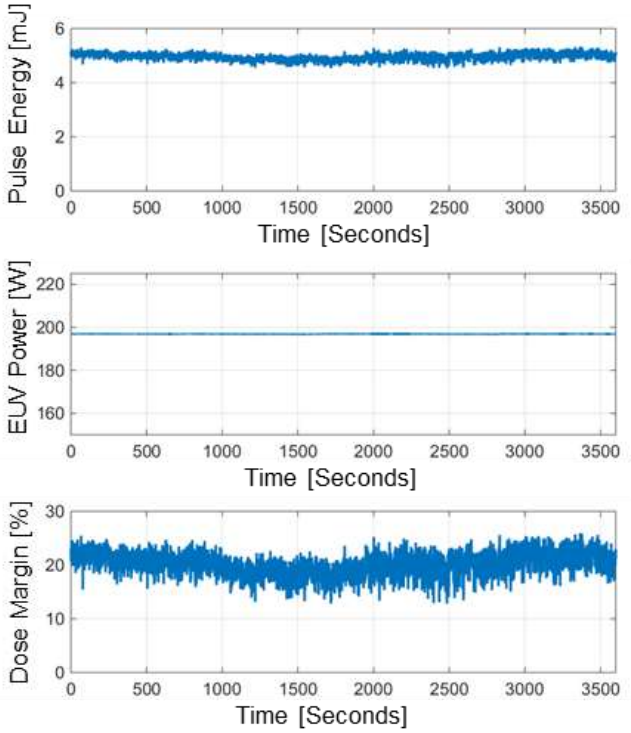


250W feasibility proven without increase in protective Hydrogen flow

No rapid collector contamination, allowing stable droplets and >125 w/hr@20 mJ/cm²



~200W dose controlled power



EUV productivity realization on track

Timing	Source power [W]	Throughput [Wafers/hr]	System availability [%]	Productivity [Wafers/day]
2015	125 ✓	>75 ✓	>70% ✓	>1000 ✓
2016	250 ✓	>125 ✓	>80% ✓	>1500 ✓

✓ **Done**

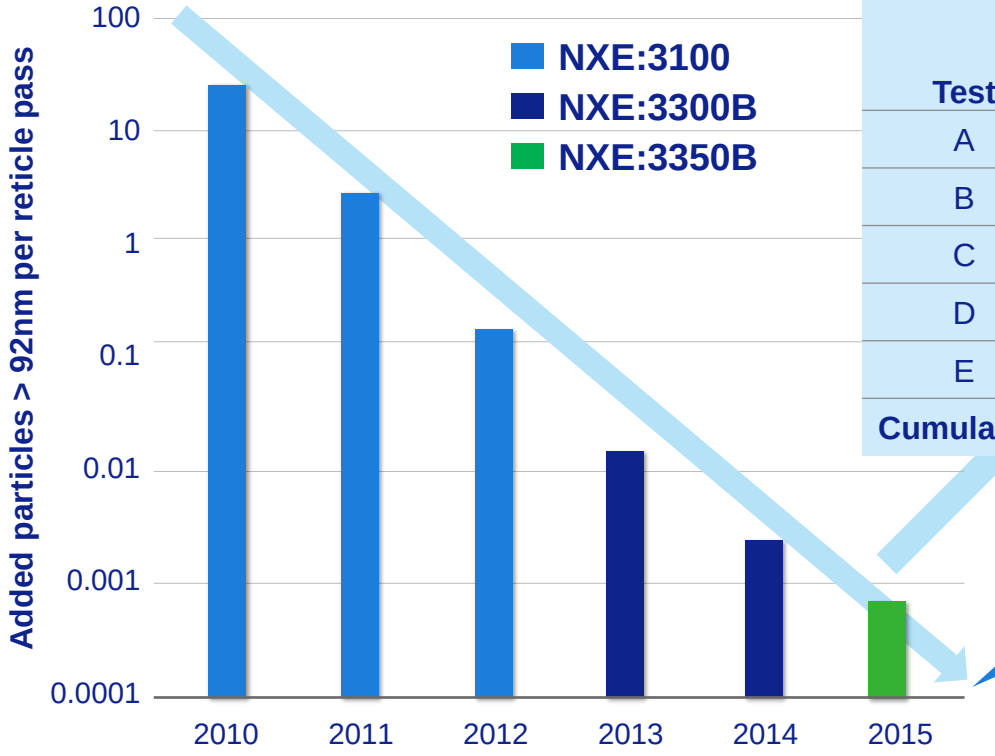
✓ **Capability demonstrated**

✓ **On track**

Outline

- Throughput & Wafers per Day (WpD)
- Availability
- Defectivity, imaging and overlay

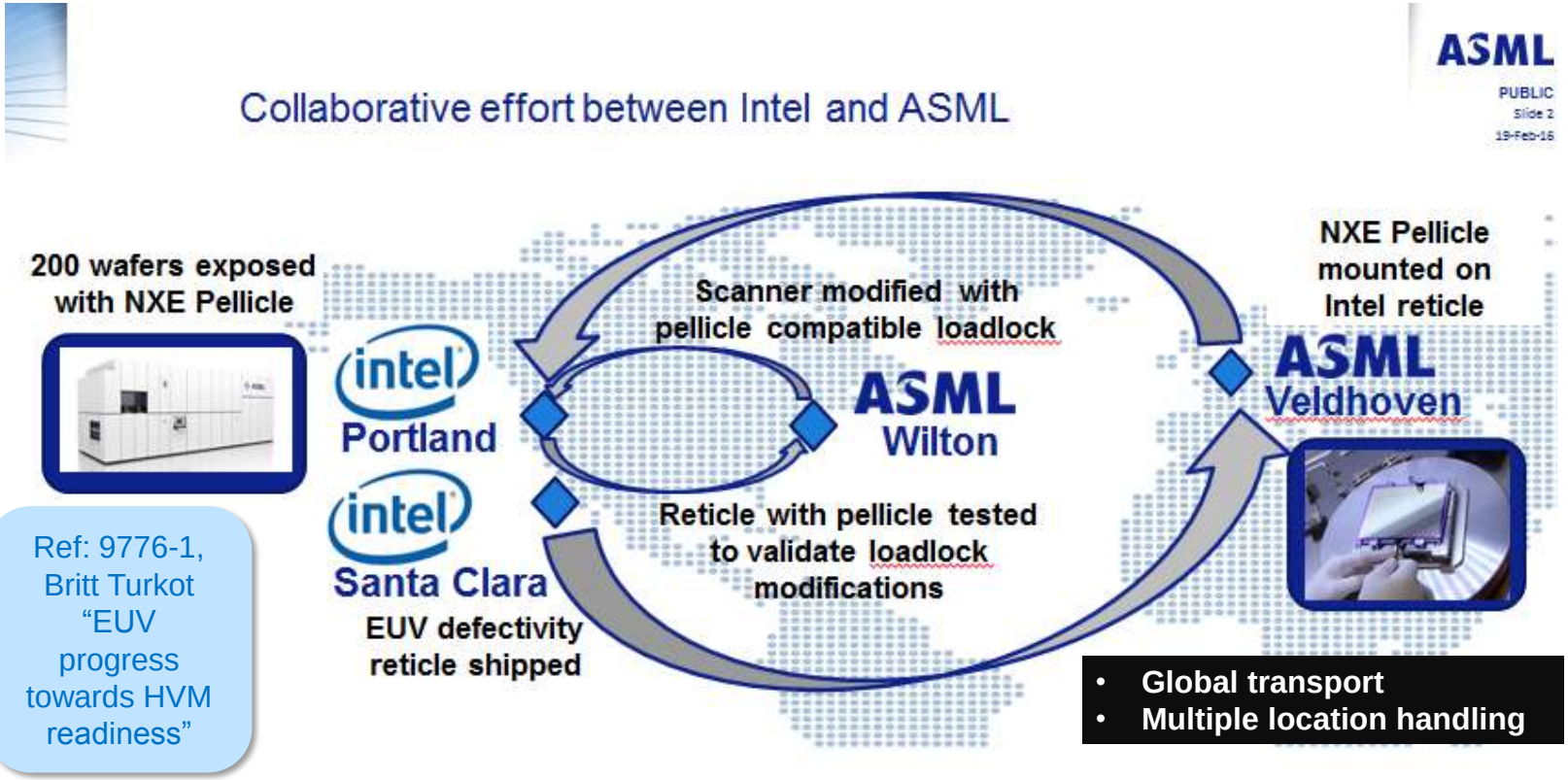
Front-side reticle defectivity: 10x reduction/year realized



Test	# Cycles	# Added Particles	PRP Value
A	228	0	<0.004
B	140	0	<0.007
C	450	0	<0.002
D	222	1	0.0045
E	133	0	<0.007
Cumulative	**1173**	**1**	**0.0008**

Customer requirement for full production without pellicle

200 wafers exposed using reticle with 40W pellicle



Ref: 9776-1, Britt Turkot "EUV progress towards HVM readiness"

Exposure testing will continue to 1000+ wafers with NXE Pellicle

200 wafers exposed using reticle with 40W pellicle

Collaborative effort between Intel and ASML

ASML

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Slide 2
19-Feb-16

200 wafers exposed with NXE Pellicle

- **NO RETICLE ADDERS OBSERVED IN WAFER PRINTS**
- **Particles on pellicle do not appear to migrate to reticle surface**
- **ASML pellicle frame design is mitigating adder rate**
  - **defectivity assessment continuing**

Ref: 9776-1, Britt Turkot "EUV progress towards HVM readiness"

EUV defectivity reticle shipped

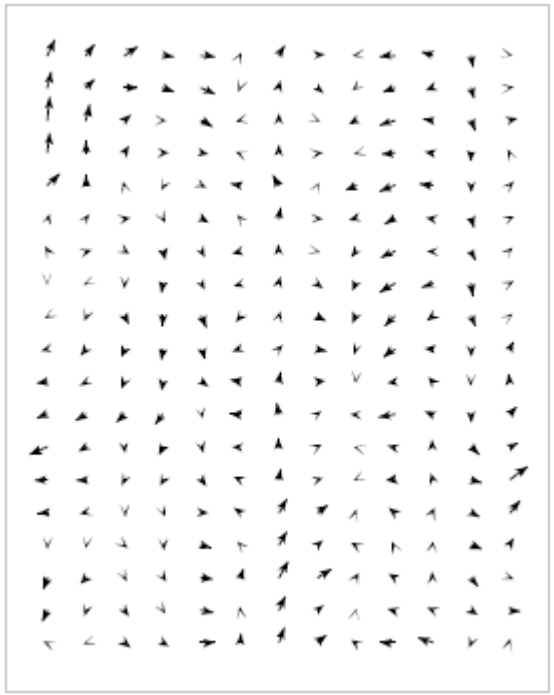
- **Global transport**
- **Multiple location handling**

Exposure testing will continue to 1000+ wafers with NXE Pellicle

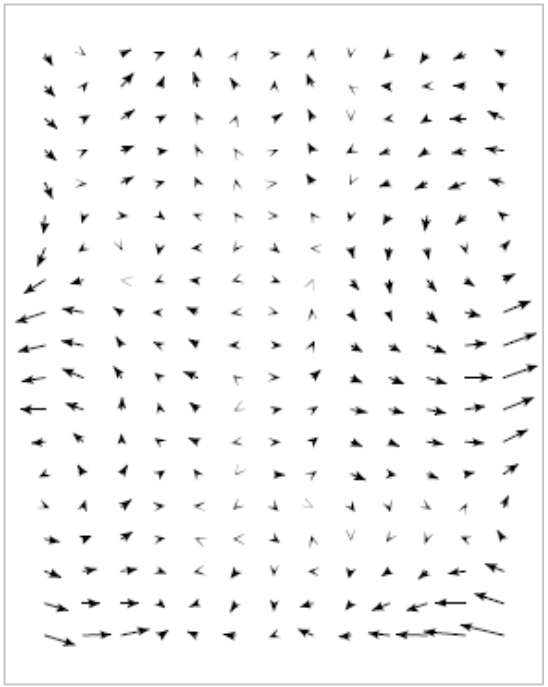
Overlay impact with NXE pellicle < 0.17 nm

Mounted on preliminary tooling; New tooling will reduce overlay further

Overlay impact reticle + studs



Overlay impact reticle + studs pellicle assy



See: 9776-71, Derk Brouns “ASML NXE pellicle update”

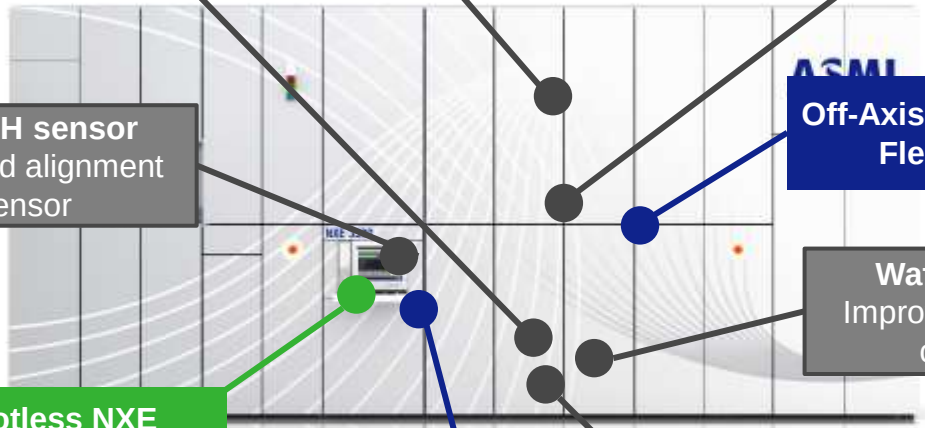
NXE:3350B: 2x overlay improvement at 16nm resolution

Completed qualification for five systems in 2015

Overlay set up
Set-up and modeling improvements

Reticle Stage
Better thermal control increased servo bandwidth

Projection Optics
Higher lens transmission improved aberrations and distortion



SMASH sensor
Improved alignment sensor

Off-Axis Illuminator FlexPupil

Wafer Stage
Improved thermal control

Spotless NXE
Automated wafer table cleaning

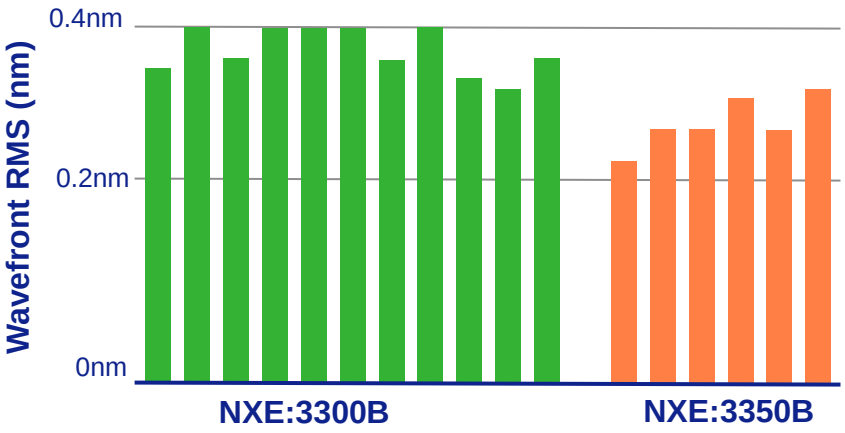
New UV level sensor

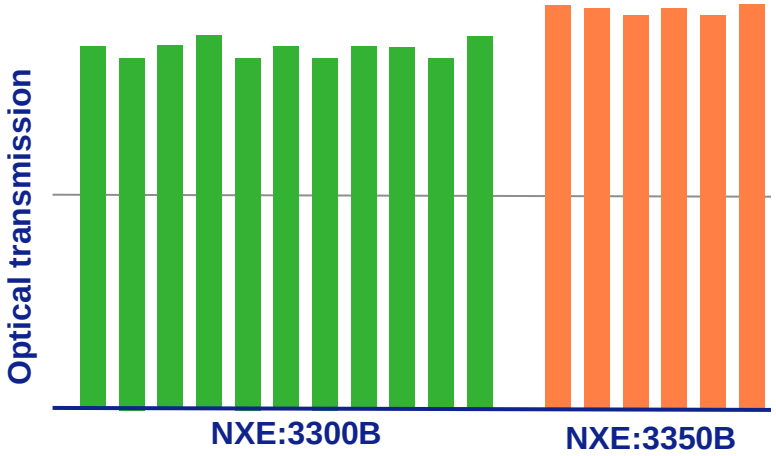
Improved air mounts

Resolution	16nm
Full wafer CDU	≤ 1.3nm
DCO	≤ 1.5nm
MMO	≤ 2.5nm
Focus control	≤ 70nm
Productivity	≥ 125 WPH

Overlay
Imaging/Focus
Productivity

Significant improvements in lens performance

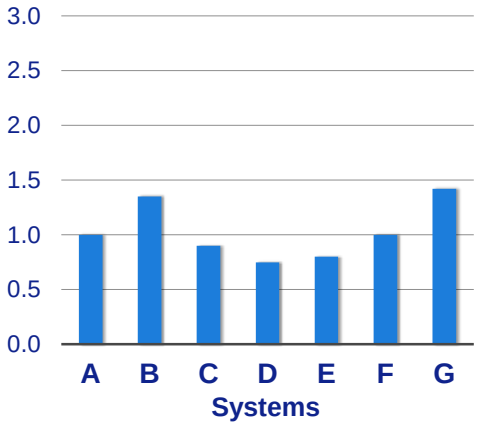


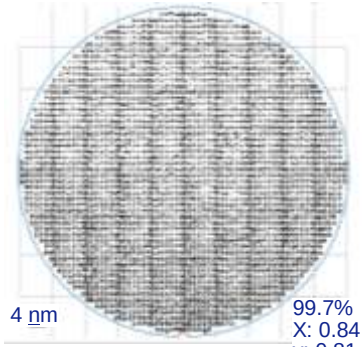


Overlay and focus performance NXE:3350B

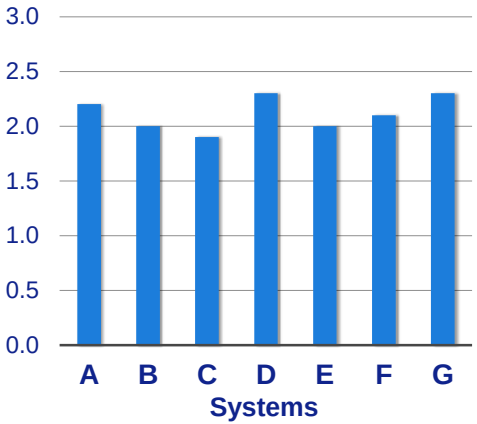
Well in specification due to Hardware improvements and new calibrations

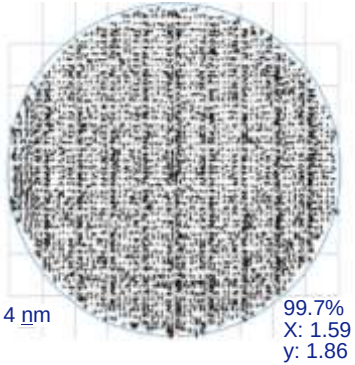
Dedicated chuck overlay [nm]



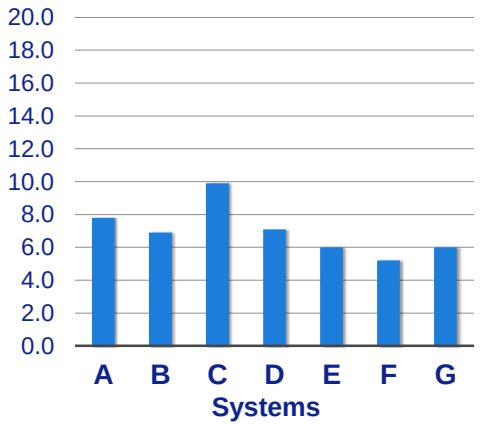


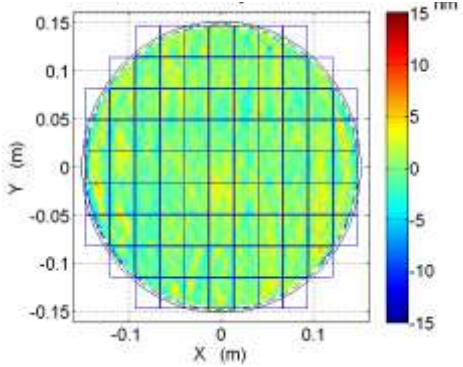
Matched machine overlay [nm]





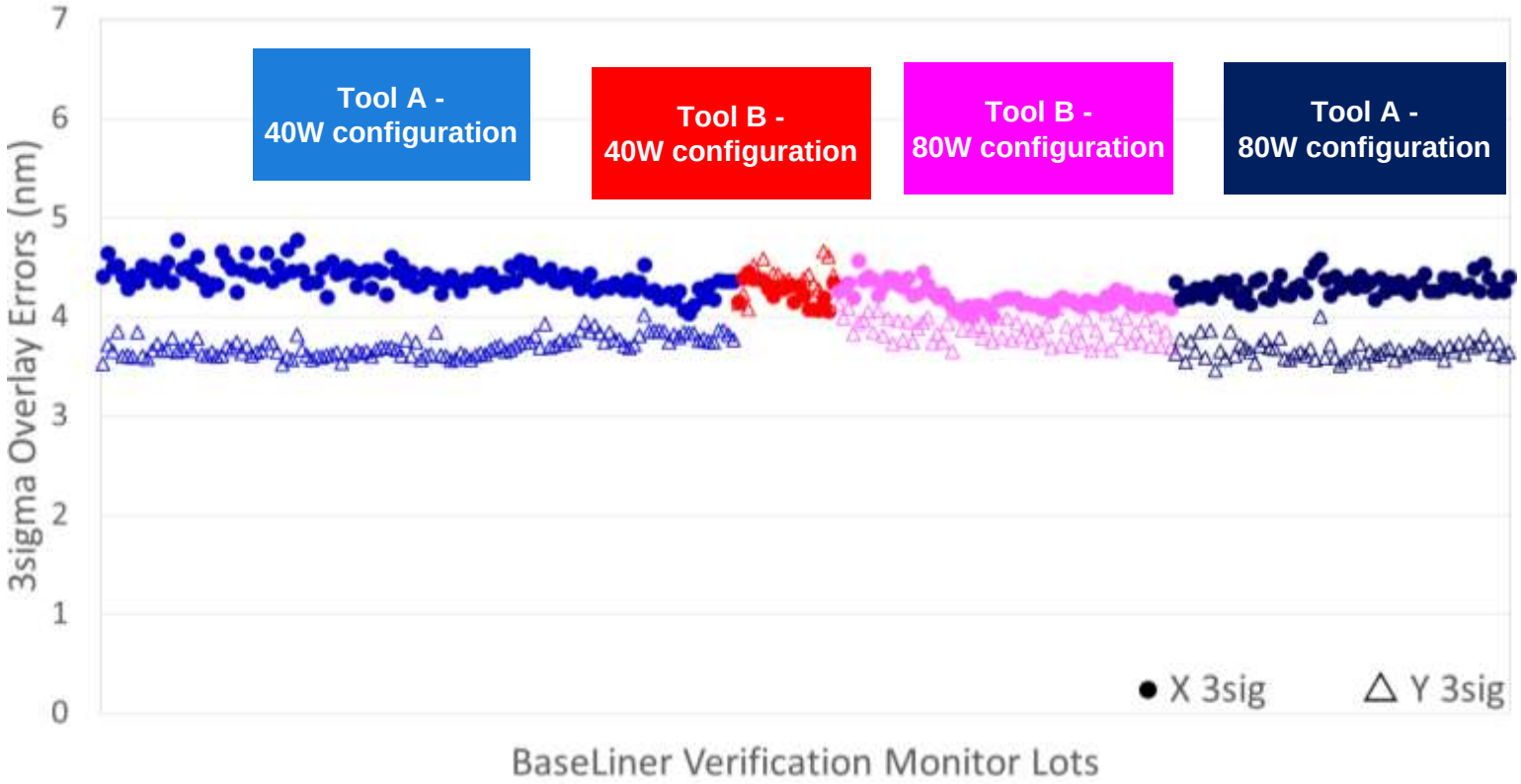
Focus uniformity [nm]





Matched machine overlay below 4.5nm for over a year

(NXE:3300B to ArF immersion)

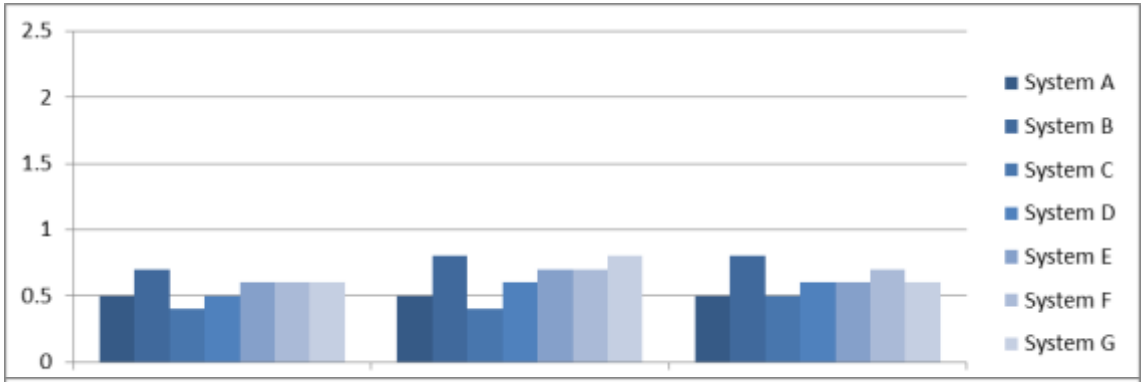


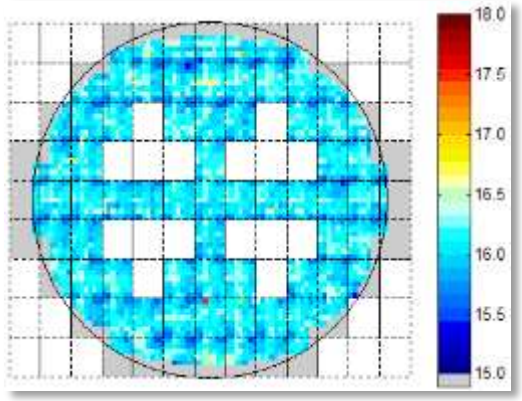
Data collected over ~18 months, no calibrations executed

Courtesy of IBM

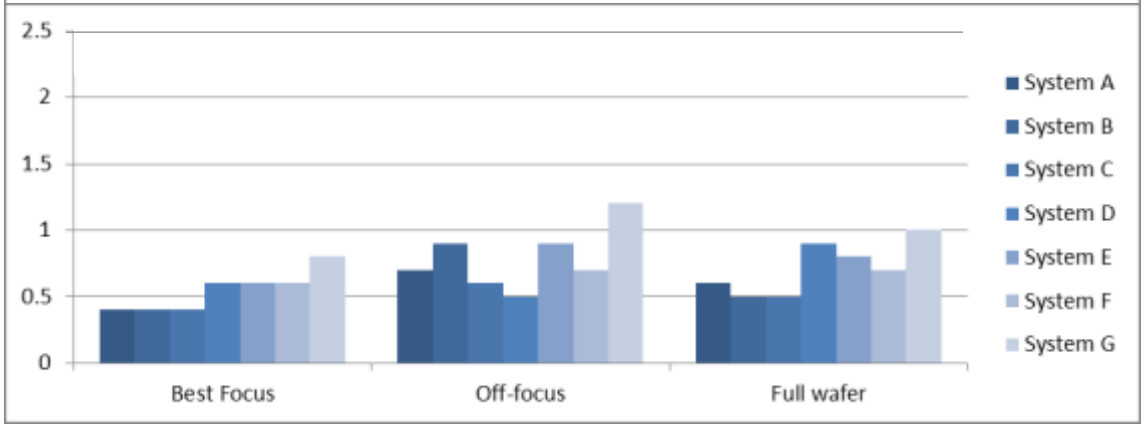
NXE:3350 Imaging: 16nm dense lines and 20nm iso space consistently achieve <1.0nm Full Wafer CDU

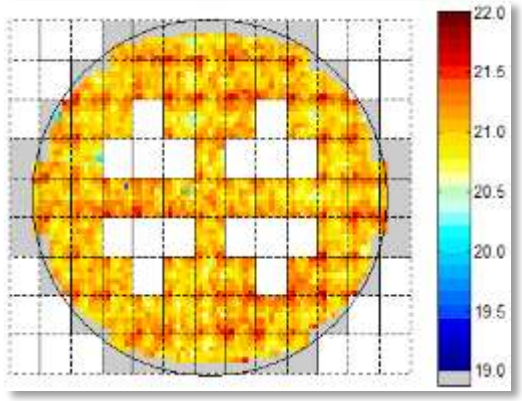
16nm dense lines





20nm iso space

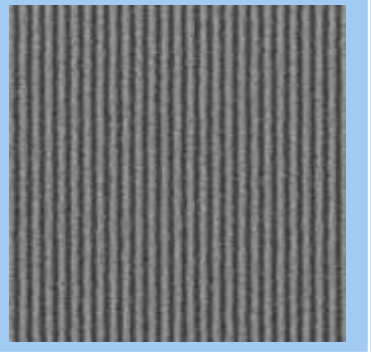
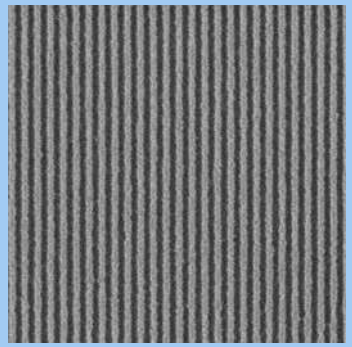
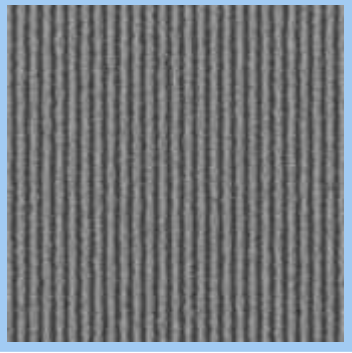




Illumination: Dipole 90 degrees. Dose ~45mJ/cm^2

New resist materials: towards 16nm resolution at full throughput

best results show 19% EL , 4.4nm LWR @ 18.5mJ/cm2

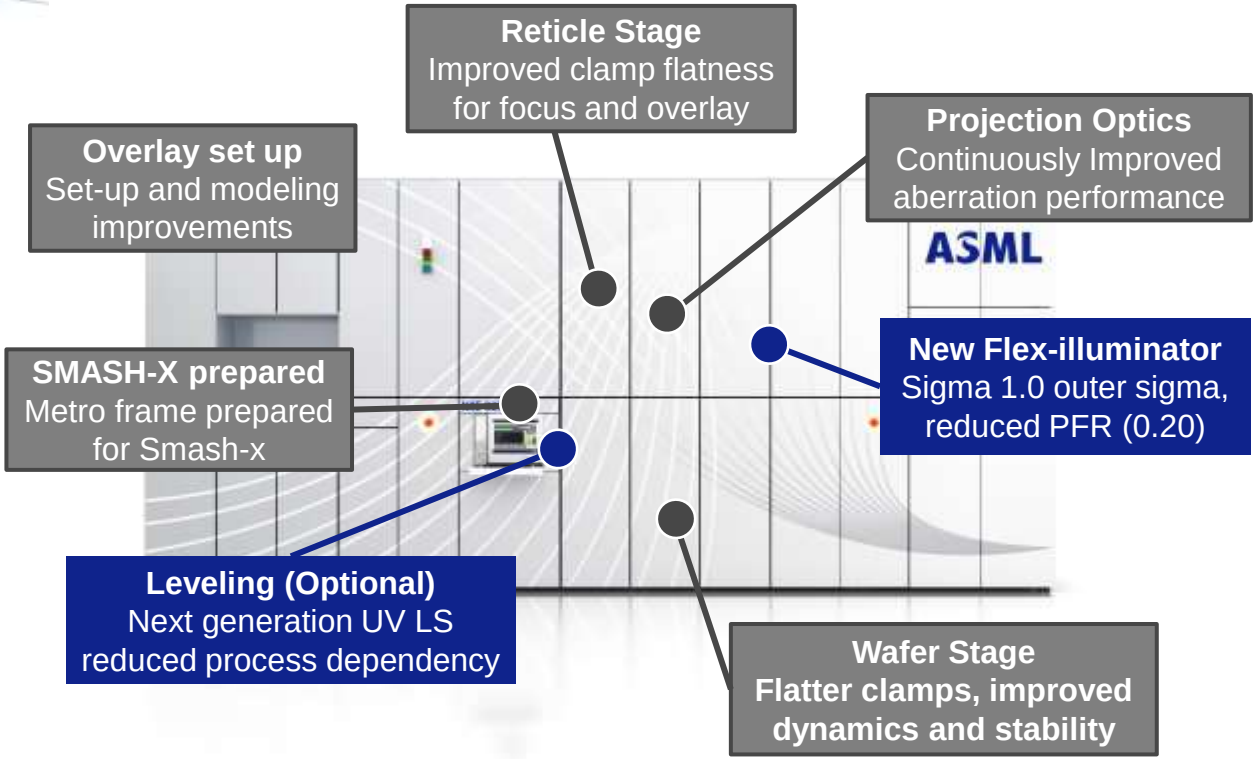
16nm Horizontal Dense lines/spaces	NXE:3350 Reference CAR	New formulation non-CAR	New formulation CAR
SEM image @BE/BF			
Dose	40 mJ/cm^2	18.5 mJ/cm^2	25 mJ/cm^2
Exposure Latitude	16 %	19 %	16 %
DoF	145 nm	125 nm	100 nm
LWR	4.6 nm	4.4 nm	5.2 nm

inpria

Exposures done on NXE:3350B system with Dipole90Y illumination. LWR: Line Width Roughness

NXE:3400B: 13 nm resolution at full productivity

Supporting 5 nm logic, <15nm DRAM requirements



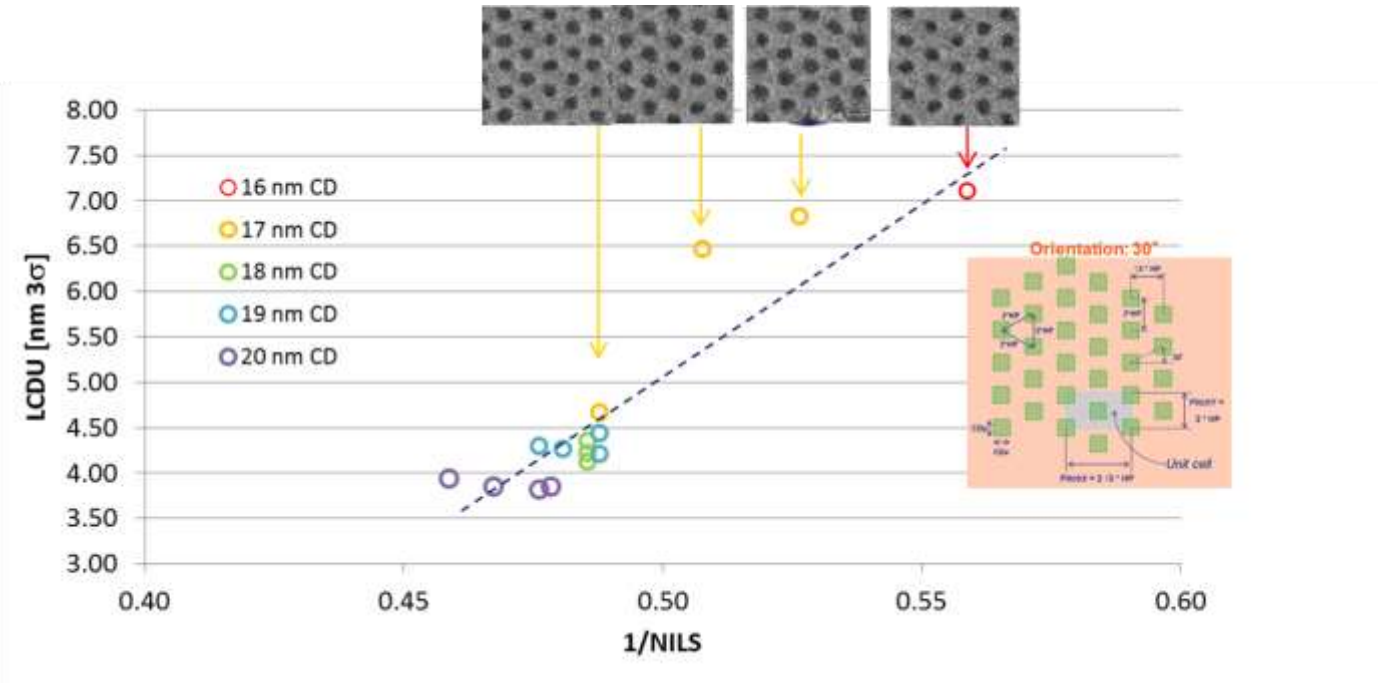
Resolution	13 nm
Full wafer CDU	≤ 1.1 nm
DCO	≤ 1.4 nm
MMO	≤ 2.0 nm
Focus control	≤ 60 nm
Productivity	≥ 125 WPH

Overlay
Imaging/Focus
Productivity

Reduction in Pupil Fill Ratio for Contact Holes contrast improvement

16 nm staggered holes resolved

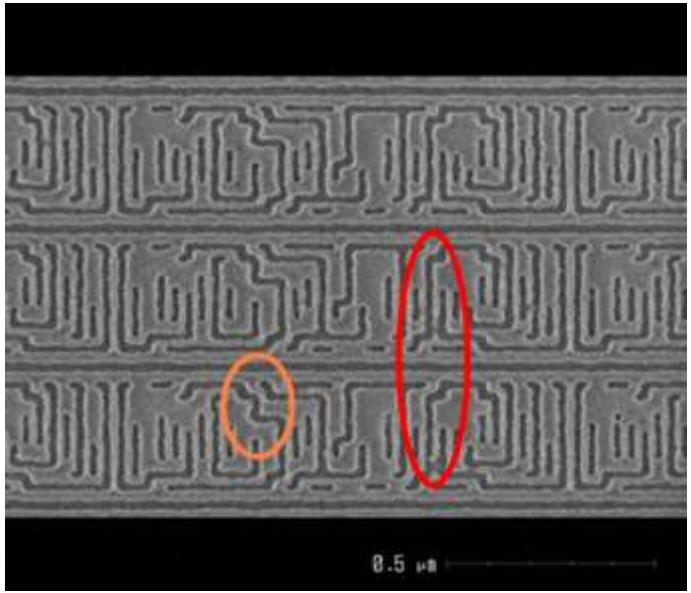
NXE 3350,
CAR hexapole
illumination
with Pupil Fill Ratio
between 10%
and 40%

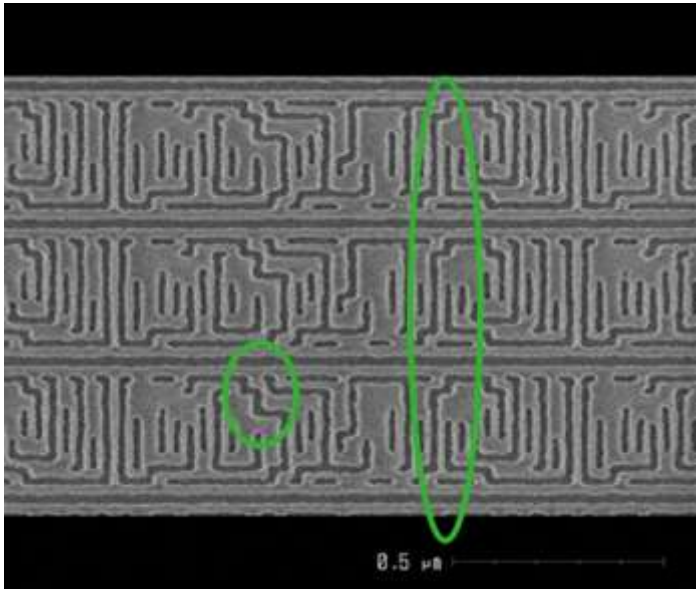


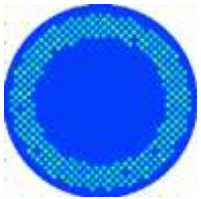
See: 9776-62, Jo Finders “Contrast optimization for 0.33NA lithography”

2D clips: pitch 32nm in x- and y- direction, k_1=0.39

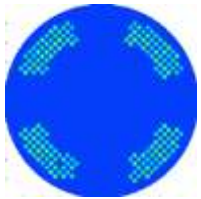
Better pattern fidelity with lower Pupil Fill Ratio







Pupil Fill Ratio=40%

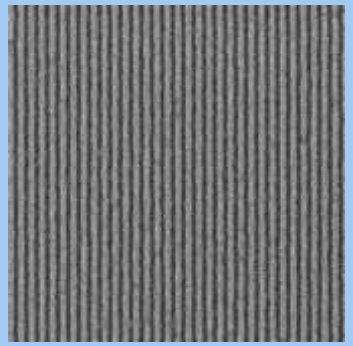
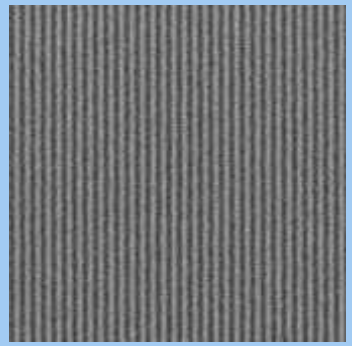


Pupil Fill Ratio=20%

See: 97762, Jo Finders “Contrast optimization for 0.33NA lithography”

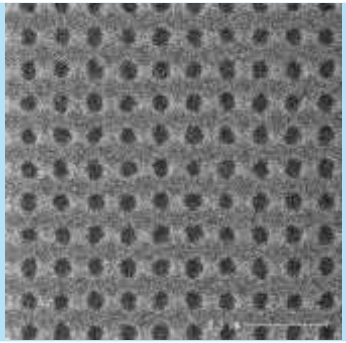
13nm Half Pitch resolved with non-CAR resist

17%EL and 4.2nm LWR @ 31mJ/cm^2 dose

13nm Horizontal Dense lines	NXE:3350 Baseline CAR	New formulation non-CAR
SEM image @BE/BF		
Dose	~40 mJ/cm^2	31 mJ/cm^2
Exposure Latitude	-	17 %
DoF	-	150 nm
LWR	4.5 nm	4.2 nm

Exposures done on *NXE:3350B* with dipole Y illumination

20nm Contact Holes: less than 30mJ/cm2 dose with non-CAR resist

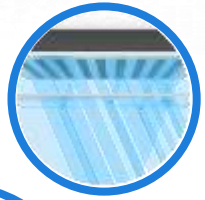
20nm Regular contact holes	New formulation non-CAR
SEM image @BE/BF	
Dose	29.5 mJ/cm^2
LCDU	3.8 nm

inpria

Exposures done on NXE:3350 with Quasar45 illumination

Summary: EUV readying for volume manufacturing

- Completed qualification of five NXE:3350B, the 4th generation EUV exposure tool, one system qualified at 75 wph
- Multiple systems demonstrated >1,000 wafers per day capability, with one system exceeding 1,350 wpd



- 80W configuration operational in the field, 125W configuration qualification completed
- 80% system availability capability demonstrated

- Excellent NXE:3350B imaging and overlay performance at> 80W power
- Continuous progress in resist formulation promising towards enabling 13nm half pitch at high throughput